8.9.2 Method of measuring the power level in a specified load (sub-clause 8.9.1.a)

This method applies only to equipment with an external 50Ω antenna connector.

Spurious radiations shall be measured as the power level of any discrete signal at the input

The substitution antenna shall be orientated for vertical polarisation and the length of the substitution antenna shall be adjusted to correspond to the frequency of the spurious component detected.

The substitution antenna shall be connected to a calibrated signal generator.

The frequency of the calibrated signal generator shall be set to the frequency of the spurious component detected.

The input attenuator setting of the measuring receiver shall be adjusted in order to increase the sensitivity of the measuring receiver if necessary.

The test antenna shall be raised and lowered through the specified range of height to ensure that the maximum signal is received.

The input signal to the substitution antenna shall be adjusted to the level that produces a level detected by the measuring receiver, that is equal to the level noted while the spurious component was measured, corrected for the change of input attenuator setting of the measuring receiver.

The input level of the substitution antenna shall be recorded as a power level, corrected for the change of input attenuator setting of the measuring receiver.

The measurement shall be repeated with the test antenna and the substitution antenna orientated for horizontal polarisation.

The measure of the effective radiated power of the spurious components is the larger of the two power levels recorded for each spurious component at the input to the substitution antenna, corrected for the gain of the antenna if necessary.

8.9.4 Method of measuring the effective radiated power (sub-clause 8.9.1.c)

This method applies only to equipment without an external antenna connector.

The method of measurement shall be performed according to sub-clause 8.9.3, except that the receiver input shall be connected to the integral antenna and not to an artificial antenna.

9. MEASUREMENT UNCERTAINTY

Absolute measurement uncertainties: maximum values

Valid up to 1 GHz[4] for the RF parameters unless otherwise stated.

RF Frequency	$\pm 1 \times 10^{-7}$
RF Power (conducted)	±0.75 dB
ERP	±3 dB
Near channel power	±5 dB
Conducted emission of transmitter	±4 dB
Conducted emission of transmitter, valid to 12.5 GHz	±7 dB
Audio output power	±0.5 dB
Sensitivity at 20 dB SINAD	±3 dB
Conducted emission of receiver	±3 dB
Conducted emission of receiver, valid to 12.75 GHz	±6 dB
Two-signal measurement, valid to 4 GHz	±4 dB
Three-signal measurement	±3 dB
Radiated emission of transmitter, valid to 4 GHz	±6 dB
Radiated emission of receiver, valid to 4 GHz	±6 dB

For the test methods according to this standard, the uncertainty figures are valid to a confidence level of 95% calculated according to the methods described in the ETSI Technical Report ETR 028: Guide-lines for estimating uncertainties in measuring methods.

[4]These values should be used between 1 GHz and 3 GHz until further notice.

ANNEXES

ANNEX A. RADIATED MEASUREMENT

A.1 Test sites and general arrangements for measurements involving the use of radiated fields

A.1.1 Outdoor test site

The outdoor test site shall be on a reasonably level surface or ground. At one point on the site, a ground plane of at least 5m diameter shall be provided. In the middle of this ground plane, a non-conducting support, capable of rotation through 360° in the horizontal plane, shall be used to support the test sample at 1.5m above the ground plane. The test site shall be large enough to allow the erection of a measuring or transmitting antenna at a distance of $\lambda/2$ or 3m

A.1.2 Test antenna

The test antenna is used to detect the radiation from both the test sample and the substitution antenna, when the site is used for radiation measurements; where necessary, it is used as a transmitting antenna, when the site is used for the measurement of receiver characteristics.

This antenna is mounted on a support such as to allow the antenna to be used in either horizontal or vertical polarisation and for the height of its centre above ground to be varied over the range 1 to 4m. Preferably a test antenna with pronounced directivity should be used. The size of the test antenna along the measurement axis shall not exceed 20% of the measuring distance.

For receiver and transmitter radiation measurements, the test antenna is connected to a measuring receiver, capable of being tuned to any frequency under investigation and of measuring accurately the relative levels of signals at its input. For receiver radiated sensitivity measurements the test antenna is connected to a signal generator.

A.1.3 Substitution antenna

When measuring in the frequency range up to 1 GHz the substitution antenna shall be a $\lambda/2$ dipole, resonant at the frequency under consideration, or a shortened dipole, calibrated to the $\lambda/2$ dipole. When measuring in the frequency range above 4 GHz a horn radiator shall be used. For measurements between 1 and 4 GHz either a $\lambda/2$ dipole or a horn radiator may be used. The centre of this antenna shall coincide with the reference point of the test sample it has replaced. This reference point shall be the volume centre of the sample when its antenna is mounted inside the cabinet, or the point where an external antenna is connected to the cabinet.

The distance between the lower extremity of the dipole and the ground shall be at least 0.3m.

The substitution antenna shall be connected to a calibrated signal generator when the site is used for spurious radiation measurements and transmitter effective radiated power measurements. The substitution antenna shall be connected to a calibrated measuring receiver when the site is used for the measurement of receiver sensitivity.

The signal generator and the receiver shall be operating at the frequencies under investigation and shall be connected to the antenna through suitable matching and balancing networks.

Note: The gain of a horn antenna is generally expressed relative to an isotropic radiator.

A.1.4 Optional additional indoor site

When the frequency of the signals being measured is greater than 80 MHz, use may be made of an indoor site. If this alternative site is used, this shall be recorded in the test report.

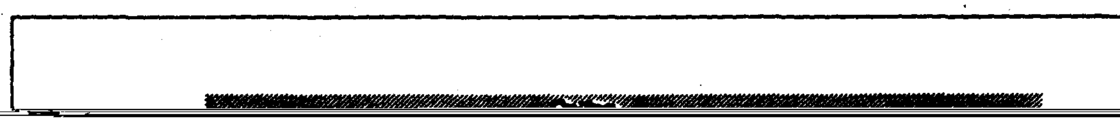
The measurement site may be a laboratory room with a minimum area of 6m by 7m and at least 2.7m in height.

Apart from the measuring apparatus and the operator, the room shall be as free as possible from reflecting objects other than the walls, floor and ceiling.

The potential reflections from the wall behind the equipment under test are reduced by placing a barrier of absorbent material in front of it. The corner reflector around the test antenna is used to reduce the effect of reflections from the opposite wall and from the floor and ceiling in the case of horizontally polarised measurements. Similarly, the corner reflector reduces the effects of reflections from the side walls for vertically polarised measurements. For the lower part of the frequency range (below approximately 175 MHz) no corner reflector or absorbent barrier is needed. For practical reasons, the $\lambda/2$ antenna in figure A.2 may be replaced by an antenna of constant length, provided that this length is between $\lambda/4$ and λ at the frequency of measurement and the sensitivity of the measuring system is sufficient. In the same way the distance of $\lambda/2$ to the apex may be varied.

The test antenna, measuring receiver, substitution antenna and calibrated signal generator are used in a way similar to that of the general method. To ensure that errors are not caused by the propagation path approaching the point at which phase cancellation between direct and remaining reflected signals occurs, the substitution antenna shall be moved through a distance of ± 0.1m in the direction of the test antenna as well as in the two directions perpendicular to this first direction.

If these changes of distance cause a signal change of greater than 2 dB, the test sample should be re-sited until a change of less than 2 dB is obtained.



A.2 Guidance on the use of radiation test sites

For measurements involving the use of radiated fields, use may be made of a test site in conformity with the requirements of sub-clause A.1 of this annex. When using such a test site, the following conditions should be observed to ensure consistency of measuring results.

A.2.1 Measuring distance

Evidence indicates that the measuring distance is not critical and does not significantly affect the measuring results, provided that the distance is not less than $\lambda/2$ at the frequency of measurement, and the precautions described in this annex are observed. Measuring distances of 3, 5, 10 and 30m are in common use in European test laboratories.

A.2.2 Test antenna

Different types of test antenna may be used, since performing substitution measurements reduces the effect of the errors on the measuring results.

Height variation of the test antenna over a range of 1 to 4m is essential in order to find the point at which the radiation is a maximum.

Height variation of the test antenna may not be necessary at the lower frequencies below about 100 MHz.

A.2.3 Substitution antenna

Variations in the measuring results may occur with the use of different types of substitution antenna at the lower frequencies below about 80 MHz. Where a shortened dipole antenna is used at these frequencies, details of the type of antenna used should be included with the results of the tests carried out on the site. Correction factors shall be taken into account when shortened dipole antennas are used.

A.2.4 Artificial antenna

The dimensions of the artificial antenna used during radiated measurements should be small in relation to the sample under test.

Where possible, a direct connection should be used between the artificial antenna and the test sample.

In cases where it is necessary to use a connecting cable, precautions should be taken to reduce the radiation from this cable by, for example, the use of ferrite cores or double screened cables.

A.2.5 Auxiliary cables

The position of auxiliary cables (power supply and microphone cables etc) which are not adequately decoupled may cause variations in the measuring results. In order to get reproducible results, cables and wires of auxiliaries should be arranged vertically downwards (through a hole in the non conducting support).

A.2.6 Acoustic measuring arrangement

When carrying out measurements of the maximum usable sensitivity (radiated) of the receiver, the audio output shall be monitored by acoustically coupling the audio signal from the receiver loudspeaker/transducer to the test microphone. On the radiation test site all conducting materials shall be placed below the ground surface and the acoustic signal is conveyed from the receiver to the test microphone in a non-conducting acoustic pipe.

The acoustic pipe shall have an appropriate length. The acoustic pipe shall have an inner diameter of 6mm and a wall thickness of 1.5mm. A plastic funnel of a diameter corresponding to the receiver loudspeaker/transducer shall be attached to the receiver surface centred in front of the receiver loudspeaker/transducer. The plastic funnel shall be very soft at the attachment point to the receiver in order to avoid mechanical resonance. The narrow end of the plastic funnel shall be connected to the one end of the acoustic pipe and the test microphone to the other.

A.3 Further optional alternative indoor test site using an anechoic chamber

For radiation measurements when the frequency of the signals being measured is greater than 30 MHz, use may be made of an indoor site being a well-shielded anechoic chamber simulating free space environment. If such a chamber is used, this shall be recorded in the test report.

The available internal dimensions of the room are 3m x 8m x 3m, so that a measuring distance of 5m length in the middle axis of this room is available.

At 100 MHz the measuring distance can be extended up to a maximum of 2λ. The floor absorbers reject floor reflections so that the antenna height need not be changed and floor reflection influences need not be considered.

All measuring results can therefore be checked with simple calculations and the measuring tolerances have the smallest possible values due to the simple measuring configuration.

For special measurements it can be necessary to re-introduce floor reflections. Taking away the floor absorbers would mean a removal of approximately 24 m^3 absorber material. Therefore the floor absorbers are covered with metal plates of metallic nets instead.

A.3.2 Influence of parasitic reflections in anechoic chambers

For free-space propagation in the far field condition the correlation $E = Eo.Z(Ro/R)$ is valid for the dependence of the field strength E on the distance R, whereby Eo is the reference field strength in the reference distance Ro.

It is useful to use just this correlation for comparison measurements, as all constants are eliminated with the ratio and neither cable attenuation nor antenna mismatch or antenna dimensions are of importance. Deviations from the ideal curve can be seen easily if the logarithm of the above equation is used, because the ideal correlation of field strength and distance can then be shown as a straight line and the deviations occurring in practice are clearly visible. This indirect method shows the disturbances due to reflections more readily and is far less problematical than the direct measurement of reflection attenuation.

With an anechoic chamber of the dimensions suggested in clause A.3 at low frequencies up to 100 MHz there are no far field conditions, and therefore reflections are stronger so that careful calibration is necessary. In the medium frequency range from 100 MHz to 1 GHz the dependence of the field strength on the distance meets the expectations very well. In the frequency range of 1 to 12.75 GHz, because more reflections will occur, the dependence of the field strength on the distance will not correlate so closely.

A.3.3 Calibration of the shielded anechoic chamber

Careful calibration of the chamber shall be performed over the range 30 MHz to 12.75 GHz.

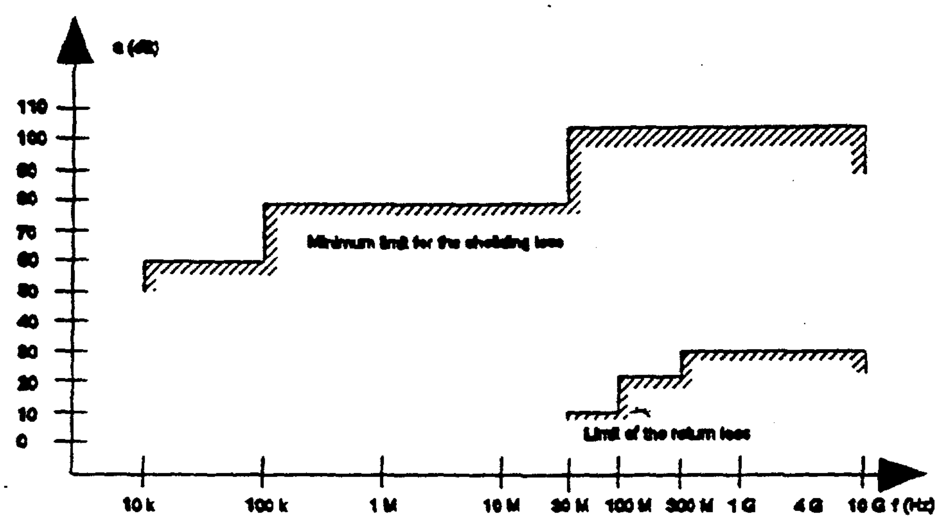
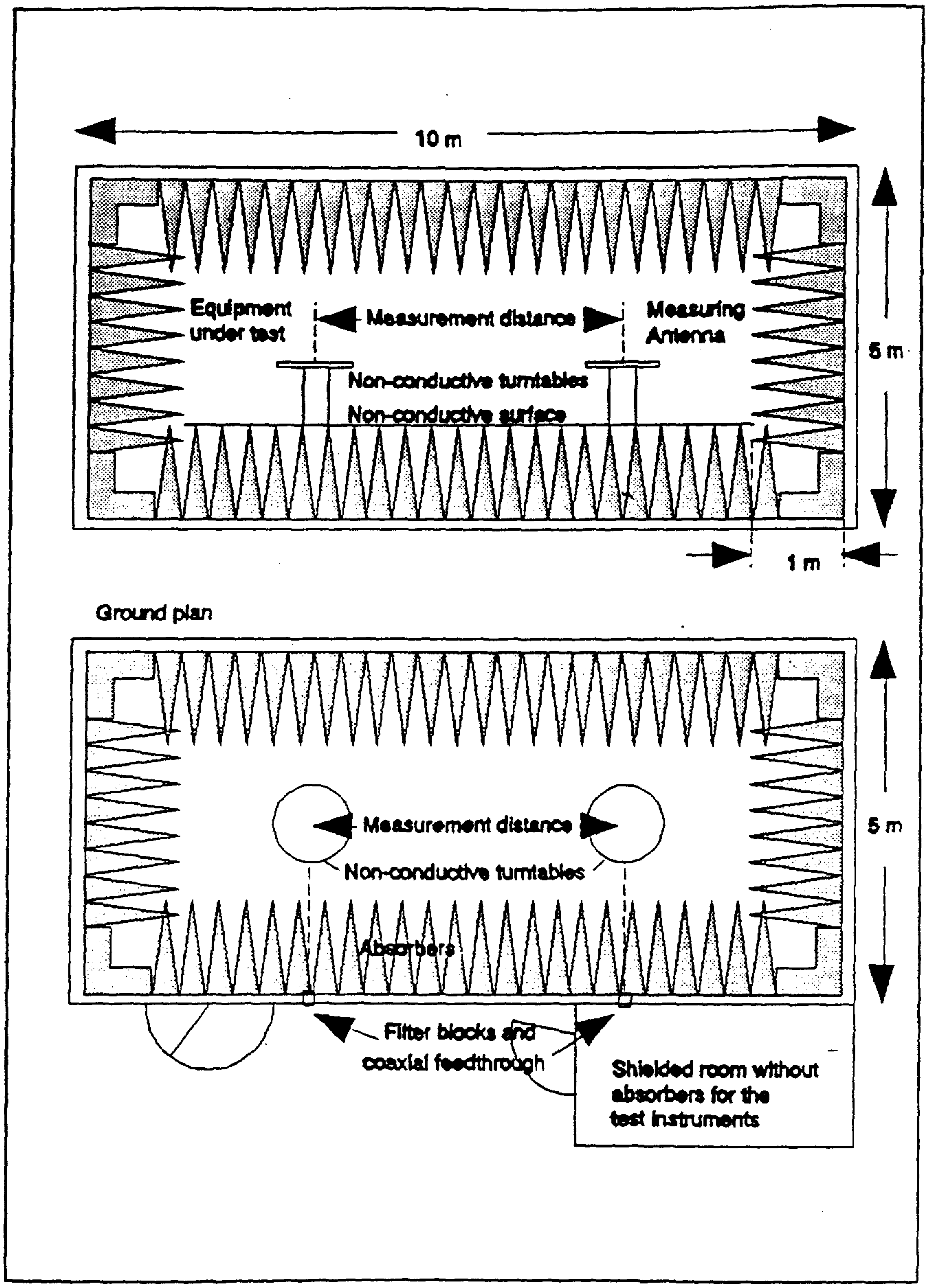


Figure A.3: Specification for shielding and reflections

Figure A.4: Example of construction of an anechoic shielded chamber



10 m
Equipment under test
Measurement distance
Measuring Antenna
5 m
Non-conductive turntables
Non-conductive surface
1 m
Ground plan
5 m
Measurement distance
Non-conductive turntables
Absorbers
Filter blocks and coaxial feedthrough
Shielded room without absorbers for the test instruments

ANNEX B SPECTRUM ANALYSER SPECIFICATION

The characteristics of the spectrum analyser shall meet at least the following requirements:

The reading accuracy of the frequency marker shall be within ±100 Hz;

The accuracy of relative amplitude measurements shall be within ±3.5 dB;

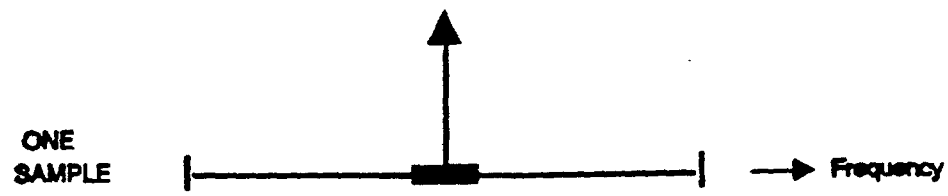
It shall be possible to adjust the spectrum analyser to allow the separation on its screen of two components with a frequency difference of 100 Hz.

For statistically distributed modulations, the spectrum analyser and the integrating device (when appropriate) must allow to determine the real power spectral density (energy per time and bandwidth), which has to be integrated over the bandwidth in question.

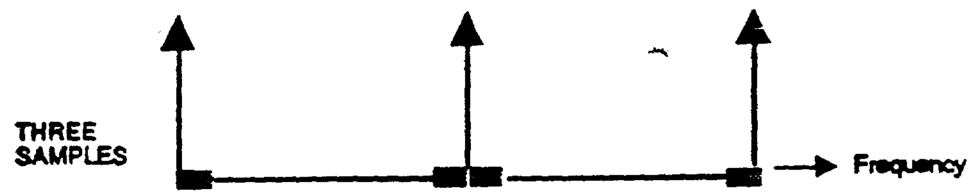
The spectrum analyser should have a dynamic range greater than 90 dB and the average phase noise in the adjacent channels or in each channel centred 10 kHz from the nominal channel centre should be -107 dBc/Hz.

ANNEX C GRAPHIC REPRESENTATION OF THE SELECTION OF EQUIPMENT AND FREQUENCIES FOR TESTING

SINGLE CHANNEL EQUIPMENT

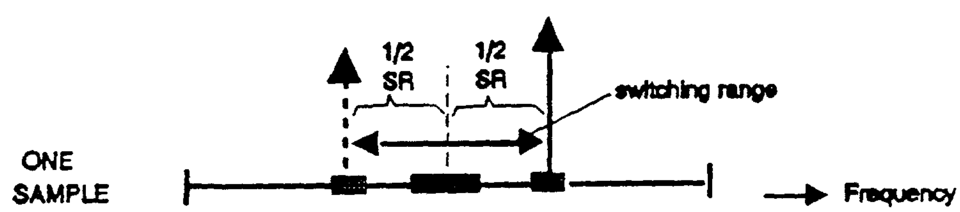


Equipment of category AR1 see clause 4.1.5

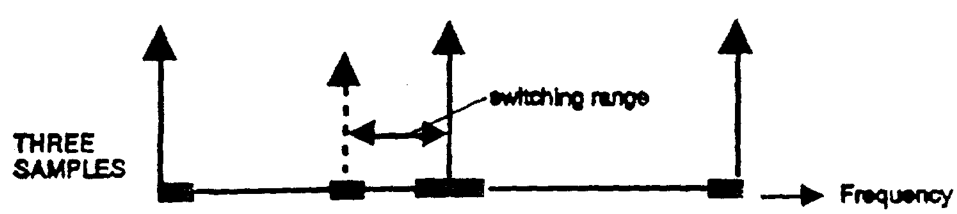


Equipment of category AR2 see clause 4.1.6

TWO CHANNEL EQUIPMENT

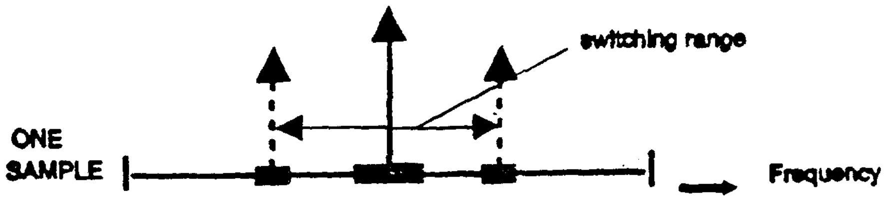


Equipment of catgory AR1 see clause 4.1.7

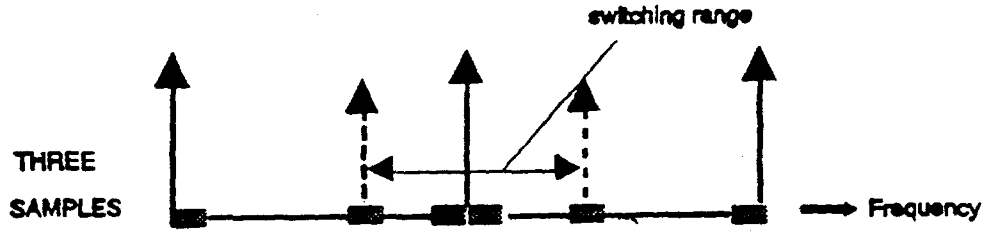


Equipment of category AR2 see clause 4.1.8

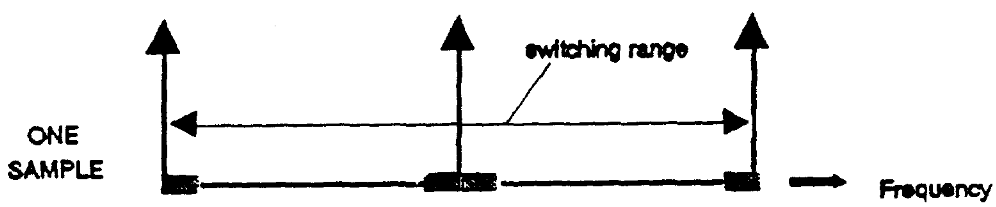
MULTI CHANNEL EQUIPMENT



Equipment of category AR1 see clause 4.1.9



Equipment of category AR2 see clause 4.1.10



Equipment of category AR2 see clause 4.1.11
AR = SR

Legend:

AR1 - First category of alignment range, clause 4.1.3.
AR2 - Second category of alignment range, clause 4.1.3.
Limited test according to, clause 3.1.
Full test according to, clause 3.1.
100 kHz range in which the test shall be carried out

Appendix 3

RADIOCOMMUNICATIONS
AGENCY

KENLEY RADIO TECHNOLOGY LABORATORY

Linear Modulation Co-Channel Compatibility Study.

PROJECT No 148

September 1992

KENLEY RADIO TECHNOLOGY LABORATORY

Linear Modulation Co-Channel
Compatibility Study.

PROJECT No 148

September 1992

Project Engineers : R Kent-Smith.
J Mennie.

Project Manager : B Ottaway.

Approved by ....

CONTENTS:

1.0 Background

1.1 The Agency is strongly committed to encouraging the use of more spectrum efficient technology. In order to alleviate congestion in the PMR bands the use of narrow band modulation techniques has become more desirable. The Agency has produced a draft specification, MPT 1376, that outlines the minimum performance standard for 5 kHz channelled equipment.

1.2 The measurements presented in this report have been made in order to establish the conditions necessary to facilitate the introduction of MPT 1376 5 kHz channel equipment to the PMR bands without excessive degradation to existing services. This report set out to determine the co-channel protection requirements of a 5 kHz channelled system from existing and proposed services.

1.3 The equipment used in these test utilised a modulation technique known as Linear Modulation (LM).

2.0 Methodology

2.1 In order to determine the protection requirement of the LM system it is necessary to establish a minimum service level. These have been defined as follows:

i) Performance of a voice channel.

This was assessed on the basis of the received signal providing 14 dB SND/ND ratio measured at the receiver output. The measurement was made at 50 % of rated output power through a telephone psophometric weighting network

ii) Performance of data channel

This was assessed on the basis of the receiver's ability to demodulate a received signal at a bit error rate (BER) no worse than 10^{-2} .

Both values are in line with the figure of merit used in draft 5.1 of MPT 1376 for the assessment of receiver two signal performance parameters.

2.2 All speech system tests were conducted with a wanted signal representing transmitter output when modulated by 1kHz audio tone. All data system tests were carried out with a 1200 baud fast frequency shift keying (FFSK) pseudo-random bit sequence.

2.3 All tests were carried out with the wanted RF signal into the receiver set to the maximum usable sensitivity level as defined in MPT 1376, and repeated at a level 15 dB above this value. These figures were chosen to give a representative results at wanted received power level at which receivers are known to give the required performance. However, the equipment available for testing's data performance was outside the limit as defined in MPT 1376.

Data quality assessment were therefore carried out at a wanted signal level which reliably gave zero error and repeated at a level 15 dB above this.

3.0 Experimental Investigation.

3.1 Equipment under test.

The measurements were carried out on a LM system which was loaned to Kenley RTL for the tests. The system's mobile transmit frequency range was 210.1375 MHz to 211.4875 MHz, with a corresponding base transmit frequency range of 209.5 MHz to 212. MHz. The equipment is designed to conform to draft MPT specification 1376 for 5 kHz channelled equipment. Full details of equipment used can be found in Appendix 2.

[illegible]

3.3 Wanted signal.

The two types of wanted signal used for the measurement are described in the following section.

3.3.1 Wanted - Speech (SINAD measurement).

To provide a signal that would produce a 1 kHz audio output from the LM receiver, two signals were combined prior to being connected to the receiver input terminal. One signal was set at a frequency equal to the receive Tone In Band (TIB) frequency, the other signal to a frequency 950 Hz above this. The amplitude of the TIB signal was 10 dB below that of the modulating tone. The level of wanted signal applied to the receiver input terminals was 6 dBuV (this was both measured maximum usable sensitivity and limit sensitivity). The measurement was repeated at a wanted level 15 dB above this (MUS + 15 dB).

3.3.2 Wanted - Data (BER measurement).

The wanted data signal was a 1200 baud FSK transmission from a LM base station. The unit's external data modem being supplied with a TTL signal from a data communications analyzer. The level of wanted signal applied to the receiver input terminals was 6 dBuV, this was the lowest signal level at which a zero error rate could be produced. The measurement was repeated at a level 15 dB above this.

3.4 Test Method.

Three separate methods were employed for assessing the performance of the LM receiver in the presence of a interfering signal, they are described in the following section.

3.4.1 Speech channel (non-DAB interferer).

3.4.1.1 The equipment was connected as shown in Appendix 1. Figure 1.

3.4.1.2 The LM receiver was supplied with a wanted signal as described in para.3.3.1. at a level equal to the limit sensitivity (MPT1376 Para. 8.1).

3.4.1.3 The unwanted signal as described in para. 3.2. was combined with the wanted signal to appear across the receiver input terminals.

3.4.1.4 The level of the unwanted signal was adjusted until the receiver SINAD ratio measurement was reduced from 20 to 14 dB. The level of the unwanted signal was calculated and noted.

3.4.1.5 The measurement was repeated at a wanted signal level 15 dB above the limit sensitivity (MUS + 15 dB). On these occasions the level of unwanted signal required to degrade the audio output to 30, 25, 20 and 14 dB SINAD were recorded.

3.4.2 Speech channel (DAB interferer).

3.4.2.1 The equipment was connected as shown in Appendix 1. Figure 2.

3.4.2.2 The LM receiver was supplied with a wanted signal as described in para.3.3.1. at a level equal to the measured maximum usable sensitivity (Para 8.1 MPT1376). The unit used for this trial did not meet the limit sensitivity requirement of MPT 1376, therefore the measured sensitivity was greater than the limit sensitivity as defined in the specification.

3.4.2.3 The unwanted signal generated by the FASS at 39 MHz was fed via a bandpass filter into a multi channel converter which upconverted the baseband frequency to the desired frequency. The signal was amplified and filtered before being combined with the wanted signal to appear across the receiver input terminals.

3.4.2.4 The level of the unwanted signal was adjusted until the receiver SINAD ratio measurement was reduced from 20 to 14 dB. The level of the unwanted signal was calculated and noted.

3.4.2.5 The measurement was repeated at a wanted signal level 15 dB above the measured sensitivity (MUS + 15 dB). On these occasions the level of unwanted signal required to degrade the audio output to 30, 25, 20 and 14 dB SINAD were recorded.

3.4.3 Data Channel.

3.4.3.1 The equipment was connected as shown in Appendix 1. Figure 3.

3.4.3.2 The LM receiver was supplied with a wanted signal as described in para. 3.3.2. at a level of equal to the limit sensitivity (MPT1376).

3.4.3.3 The unwanted signal as described in para. 3.2. was combined with the wanted signal to appear across the receiver input terminals.

3.4.3.4 The level of the unwanted signal was adjusted to the measured carrier/interference (C/I) ratio required to reduce the receiver SINAD ratio measurement from 20 to 14 dB on a speech system (as measured at para.3.4.1). The resultant bit error rate (BER) was recorded.

3.4.3.5 The level of the unwanted was then adjusted to produce the minimum service requirement. This level was also recorded.

3.4.3.6 The measurement was repeated at a wanted signal level 15 dB above the limit sensitivity (MUS + 15 dB). On these occasions the C/I ratio required to produce degradation in the audio output to a SINAD ratio of 30, 25, 20 and 14 dB (as measured at para.3.4.1) on a speech system was applied to the data system.

4. Test Results.

Full tabulated results of each test can be found in Appendix 3.

Results appear in a graphical format at Appendix 4.